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Kavtaradze, Lasha

12 July 2014

Online at <https://mpra.ub.uni-muenchen.de/59966/>

MPRA Paper No. 59966, posted 17 Nov 2014 16:00 UTC

# Inflation Dynamics in Georgia

Lasha Kavtaradze\*

July 12, 2014

## Abstract

This paper examines inflation dynamics in Georgia using a hybrid New Keynesian Phillips Curve (NKPC) nested within a time-varying parameter (TVP) framework, which incorporates both forward-looking and backward-looking components. Estimation of a TVP model with stochastic volatility shows low inflation persistence over the entire time span (1996-2012), while revealing increasing volatility of inflation shocks since the “Rose Revolution” in 2003. Moreover, parameter estimates point to the forward-looking component of the model gaining importance following the National Bank of Georgia (NBG) adoption of inflation targeting in 2009. However, since 2011 the inertia of the expected future inflation takes a declining process while the backward-looking (lagged) component gradually climbs upward, thus, challenging the NBG in revising its target benchmark of 6%.

JEL: E31, E32, E52, E58

Keywords: Inflation dynamics, Georgian economy, hybrid NKPC models, time-varying parameters, MCMC sampling method, Kalman filter.

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\*Lasha Kavtaradze, Università Cattolica del Sacro Cuore, Milan 20123, Italy. Emails: lasha.kavtaradze@unicatt.it, l.kavtaradze@ymail.com

# 1 Introduction

In recent years, the preservation of price stability has become an explicit mission for several Central Banks, such as the Georgian Central Bank<sup>1</sup>. Price stability requires a credible monetary policy that would reduce persistence and variability of inflation through anchoring its expectations. This is important because it reduces the cost of lowering inflation (in overheating periods) in terms of real output, and it provides the foundation for all kinds of economic activity and people's livelihood.

There are many theories postulating the existence of a stable tradeoff between inflation and economic activity. While stimulating economy accelerates inflation, the contrary is not true. It is a misunderstanding to say that high economic growth requires high inflation<sup>2</sup>. In fact, empirical analysis of international data indicates a negative relationship between inflation rate and economic growth (Barro 2013)<sup>3</sup>.

The recent empirical works mainly rely on the New Keynesian Phillips Curve (NKPC), exploring the relationship between inflation and real economic activity<sup>4</sup>. Two types of NKPCs are known in empirical studies – a “pure” NKPC and a “hybrid” NKPC. In this paper, a “hybrid” NKPC is used to model and analyze inflation dynamics in Georgia. Despite its flaws, the NKPC has shown

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<sup>1</sup>The National (Central) Bank of Georgia has existed since 1991. But, until 1993 Georgia was included in the Maneti zone (currency of the Soviet Union). Thus, it could not emit its own money in the economy. After the Russian Federation stopped its provision of money to the Georgian economy, Georgia created a form of temporary money, namely “Coupon,” which lasted until 1995. In 1995, Georgian's current currency (Lari) replaced the Georgian “Coupon”. The Constitution of Georgia explicitly dictates the independence of the National Bank of Georgia in its activities.

<sup>2</sup>See figure 1 in appendix 1.

<sup>3</sup>Using data for around 100 countries from 1960 to 1990, Barro (2013) finds that an increase in average inflation by 10 percentage points per year reduces the growth rate of real per capita GDP by 0.2-0.3 percentage points per year.

<sup>4</sup>The NKPC uses a dynamic general equilibrium model to provide a framework for the inflation process. The NKPC incorporates the idea that imperfectly competitive firms face constraints on price changes. Thus, the NKPC integrates the Keynesian features of nominal rigidities that are the foundation of the imperfect competition into a microeconomic dynamic optimizing framework.

to work well in describing inflation dynamics. Galí and Gertler (1999), Galí, Gertler and Lopez-Salido (2001), Galí and Lopez-Salido (2001), Balakrishnan and Lopez-Salido (2002), Batini, Jackson and Nickell (2005), and Muto (2006) use this model and show the usefulness of their empirical analysis for describing events in the US, Spain, UK, and Japan. Rudd and Whelan (2007), Lindè (2005), Bjørnstad and Nymoen (2008) and Dufour, Khalaf and Kichian (2006) argue that this model may not provide an optimal framework for explaining the inflationary dynamics. Nonetheless, to capture forward-looking expectations of inflation, the hybrid NKPC model adds a backward-looking component which helps in explaining inflation evolution by squeezing specification errors.

The use of monetary policy in Georgia to control inflation was not successful until 2000. During the period 2000-2006 inflation rates were within the single digit range of 4-9 percent<sup>5</sup>. There are some years (2007, 2008 and 2011) when inflation hovered around double digits at 10-11 percent. However, it is an interesting case, when the economy with high inflation, suddenly, headed towards deflation in 2012-2013. It is therefore a first motivation to analyze the source and nature of inflation, which is an immediate interest to the Central Bank of Georgia (NBG) and is tasked with the preservation of price stability in the Georgian economy.

Another motivation is the lack of research papers devoted to analyze inflation dynamics in Georgia, especially, there are no research studies focused on inflation dynamics using NKPC models. Accordingly, this paper has a twofold contribution to the literature. First, we present novel empirical evidence by applying the hybrid NKPC nested within the time-varying parameter (TVP) model to the Georgian data and, second, we provide an appropriate policy analysis for understanding and pursuing an optimal course of action by the NBG.

Several studies show that political and social-economic situations have been

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<sup>5</sup>See figure 8 in appendix 1.

changing across many countries over the last couple decades. Structural changes always pose challenges to the authorities in charge of the country's monetary policy. This is a major reason for adopting inflation targeting as the main policy regime by the central banks (Benati, 2008). Originally, inflation targeting is a policy framework to enhance the transparency regarding the conduct of monetary policy and to strengthen the credibility of the commitment to price stability. Georgia, as a transition country, has not been immune to the internal and external shocks<sup>6</sup>. In the last two decades, Georgia has witnessed four major changes in its government. Also, as a small open economy, Georgia has been susceptible to the full force of external shocks that have left major impacts on its economy. From the macroeconomic modeling point of view, the structural changes are caused by various shocks might be captured by the extension component of the hybrid NKPC.

Therefore, the paper tries to answer the following questions: Does the Inflation Targeting (IT) regime have a decisive applicability to the future path of inflation? What are the roles of forward-looking and backward-looking expectations in observed inflation dynamics?

To analyze the factors that drive inflation in Georgian economy, we investigate an open economy version of the hybrid NKPC nested within the TVP framework. The model is an extension of a model that was developed earlier by Galí and Monacelli (2005). For estimating the TVP regression model with stochastic volatility the Markov Chain Monte Carlo (MCMC) method (Nakajima, 2011) is used. Advantages of the time-varying coefficient procedure are that it corrects specification errors as a result of incorrect functional forms, omitted variables, and measurement errors in the NKPC model (Hall, Hondroyannis, Swamy and Tavlas, 2009), and, besides that, it helps alleviate the identification problem by making more efficient use of the information available

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<sup>6</sup>Huge amount of FDI inflows, suddenly in 2007.

in the data.

Using Georgian macroeconomic data, the estimation results for the hybrid model reveal the time-varying structure of the Georgian economy. The results show that the forward-looking component dominates the inflation dynamics in Georgia. However, important structural changes in the economy over time are observed as well. Analysis shows that, the backward-looking component gradually increased after 2005 until the Central Bank adopted a inflation targeting regime in 2009. During 2009-2011, expected future inflation influenced the inflations, but later the nature of inflation noticeably changed. The analysis also shows that the volatility of inflation shocks grew until 2006, but then reversed a little. The estimated cyclical coefficient, which is significant, shows high correlation with the lagged inflation. The relative importance of the factors of foreign inflation, monitored by the terms of trade, is relatively negligible as well, which suggests that extraneous factors may already be integrated in both lagged- and future inflation expectations themselves. These findings show that the role of the monetary policy in achieving the objective of price stability has been less than successful<sup>7</sup> and have important policy implications for the authorities in the NBG.

Drawing upon the nature of inflation, the model facilitates further works on the determining of optimal level of inflation, which is at the heart of policy making for a stable and growing economy. In the past, Georgia has experienced high levels of inflation, interest rate, budget deficit, dollarization, and dependency on imports. However, Georgia has experienced a tendency towards deflation. There is a consensus among economist that disinflation (moving to-

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<sup>7</sup>Monetary policy to be successful, the Central Bank must have an accurate assessment of the timing and the effects of their policy on the economy, thus requiring an understanding of the mechanism through which monetary policy affects the economy" (Mishkin 1996). Therefore, formulation and implementation of appropriate monetary policy is the major responsibility of central banking.

wards deflation) slows economic growth<sup>8</sup> . However, Ball (1994) and others have found that with a credible monetary policy and a right specification of staggering, an accelerated disinflation can in fact cause a boom rather than a recession.

Finding an optimum level of inflation for the Georgian economy is of paramount importance for the monetary authorities who are charged with price stability in Georgia. Clearly, finding the Ramsey optimal inflation rate for the Georgian economy is a significant contribution to policy making in Georgia. However, this poses an interesting challenge that will require a good understanding of the Georgian experience and its data, careful modeling and estimation, and in-depth analysis of the results.

The remainder of this paper is structured as follows. Section 2 describes a review of the existing literature from the empirical point of view. Section 3 presents the strategy of the model. Section 4 provides the Georgian macroeconomic data. The fifth section reports on the empirical results. The final remarks are presented in section 6. Appendix contains figures, tables, and estimates.

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<sup>8</sup>In addition, deflation may raise the real value of enterprise debt and, hence, may reduce the firms' interest in investment; and anticipation of wage and price deflation may depress demand by consumers and investors.

## 2 Related Literature

In their popular seminal paper, Galí and Gertler (1999, henceforth, GG) developed a hybrid model of the New Keynesian Phillips Curve (NKPC), which proposes a variation of Calvo’s (1983) staggered contract model. They depart from the Calvo’s model and assume that a fraction ( $\varepsilon$ ) of the firms set price equal to the average of newly adjusted prices last period plus an adjustment for expected inflation, i.e. GG allows a fraction of firms to be backward-looking, and a fraction  $(1 - \varepsilon)$  will choose prices optimally (on the basis of expected future marginal costs). Later, Galí, Gertler and Lopez-Salido (2001) introduced the hybrid model<sup>9</sup> that is a generalization of GG, which allows increasing marginal cost. For estimating the hybrid NKPC model, GG used GMM techniques, which was criticized by Rudd & Whelan (2005) and Mavroeidis (2005), based on an argument that GMM does not perform well and is highly sensitive to the choice of instrument set, characterizes to weak identification and small sample bias. Extension of the hybrid NKPC is referred to Galí and Monacelli (2005) constructing a new hybrid NKPC model by adding a forcing variable – terms of trade<sup>10</sup> – and performed an open economy version of the NKPC (this model implicitly assumes exchange-rate pass-through), and represents as a basis of my paper. An empirical evidence of this model is provided by Mihailov (2011a)<sup>11</sup>.

Understanding of generation process of time-varying parameters, Lansing (2008) examined a form of boundedly-rational inflation expectations in the NKPC, assumed that expected inflation is an exponentially-weighted MA process of past observed inflation. By deriving autocorrelation coefficient, the agent can identify the “signal-to-noise” associated with a Kalman gain parameter from the Kalman filter. Lansing showed that the variable-gain version of the model

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<sup>9</sup>Original version of the derivation of the hybrid NKPC, see appendix 3.

<sup>10</sup>In the model it is associated as an imported inflation.

<sup>11</sup>Details in table 2, in appendix 1.



generates time-varying persistence and volatility.

The bulk of papers shows no importance of lagged inflation term in NKPC models. For instance, in spite of theoretical supports (Cogley & Sbordone (2008)) of inflation is persistence to arise in the NKPC, due to the fact that monetary policy shifts over time, was not approved playing with US data. Approaching an unrestricted VAR in the first step with drifting parameters and stochastic volatility, and then estimating the price model by exploiting cross-equation restriction on the VAR parameters, US inflation dynamics was explained very well without the introduction of ad hoc backward-looking terms in the NKPC. From a different approach, Hondroyannis, Swamy and Tavas (2009) estimated the NKPC using the time-varying coefficient (TVC) estimation for France, Germany, Italy, and the UK, and found support for the NKPC model that excludes lagged inflation – no inertial element of inflation. For the benchmark set of results, as in many other papers, they applied GMM techniques with no corrections for specification biases to the hybrid NKPC (here lagged inflation was positive and significant).

Baxa, Plasil and Vasicek (2012) estimated both closed and open economy versions of the hybrid NKPC model using the TVP regression model like Kim (2006) but slightly modified – they used Bayesian Model Averaging (BMA) in the first step instead of OLS and in the second step the hybrid NKPC with stored standardized residuals from the first step was nested and estimated in the time-varying-parameter (TVP) framework. They found evidence that the forward looking inflation term was more important than the backward looking one for the three Central European (CE) countries – Czech Republic, Hungary and Poland. Besides that inflation persistence has almost disappeared only in the Czech Republic. The volatility of inflation shocks had a downward path after the adoption of the inflation targeting regime in the Czech Republic and

Poland, and was stable in Hungary.

Allowing for random changes of economic regimes and then measuring inflation persistence (to analyse inflation dynamics) for the six Central and South-Eastern countries by using the univariate approach, Mladenovic and Nojkovic (2012) revealed a moderate to high magnitude inflation persistence in Hungary, Poland, Serbia and Romania and a small moderate inflation in Slovakia and Czech Republic. Application of the NKPC model represented a valid structural approach of describing inflation evolution in the region. The weights of backward- and forward looking inflation are significant but the estimated element of the latter term does not play a dominant role over the former one.

However, a paper is beyond the scope of estimating the NKPC, Maliszewski (2003) finds the existence of low inflation persistence in Georgia by using error-correction models (ECM). Moreover, It shows that short-run dynamics of inflation are strongly affected by current exchange rate change, money growth, and changes in relative prices of foodstuffs and in oil prices.

Unfortunately, there are not many research papers that have studied the inflation dynamics in Georgia. In the past, scarcity of data has been the main reason for scant attention to a full scale modeling and analysis of the inflation dynamics in Georgia<sup>12</sup>. In particular, there is no research that has focused on inflation dynamics using the NKPC estimation with TVP framework. The paper overcomes the challenge by collecting sufficient macroeconomic data that enables me to estimate a small open economy version of the hybrid NKPC for the analysis of the inflation dynamics in Georgia. The findings point to the optimum level of inflation for the Georgian economy, which is of paramount importance for the monetary authorities who are charged with price stability in Georgia. Thus, the estimated results of this paper allow me to significantly contribute to the monetary policy analysis and policy making process in Georgia.

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<sup>12</sup>For application of ECM to Georgian data see: Barbakadze (2008).

### 3 Modeling Strategy

#### 3.1 The Core Model

Since Georgia is a small open economy—an economy that is, especially, highly dependent on imports—this empirical analysis extensively refers to the hybrid NKPC model of Galí and Monacelli (2005) who allow for these characteristics.

This model rests on the Calvo’s price environment assumptions that some firms follow a backward-looking rule of thumb in updating their prices with the past inflation, while others do not; i.e., the rest of the firms are forward-looking in their pricing (GG, 1999 and Galí et. al, 2001). The hybrid NKPC model

$$\pi_t = \omega_f E_t \pi_{t+1} + \lambda s_t + \omega_b \pi_{t-1} + \mu_t \quad (1)$$

shows that the actual inflation  $\pi_t$  is a function of the expected inflation  $E_t \pi_{t+1}$ , the current real marginal cost  $s_t$  and the past inflation  $\pi_{t-1}$ . In this model,  $\mu_t$  is an error term<sup>13</sup>, while  $\omega_f$ ,  $\omega_b$  and  $\lambda$  are potentially time-varying<sup>14</sup> parameters. These parameters, i.e.,  $\omega_f$ ,  $\omega_b$  and  $\lambda$  are convolutions of some structural parameters that we may denote by  $\beta$ ,  $\theta$  and  $\omega$ <sup>15</sup>:

The reduced form parameter  $\lambda$  is defined as:

$$\lambda = \frac{(1 - \omega)(1 - \theta)(1 - \beta\theta)}{\theta + \omega[1 - \theta(1 - \beta)]}$$

$$\omega_f = \frac{\beta\theta}{\theta + \omega[1 - \theta(1 - \beta)]}$$

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<sup>13</sup>It is an exogenous inflation shock.

<sup>14</sup>The time-varying system derives from the dynamic economic conditions taking place in unstable economies.

<sup>15</sup> $\beta$  is a subjective discount factor;  $\theta$  measures price stickiness, and  $\omega$  is fraction of backward-looking price setters. See more details in appendix 3.

$$\omega_b = \frac{\omega}{\theta + \omega[1 - \theta(1 - \beta)]}$$

Now, consider a NKPC model taking into account external factors - openness of the economy. According to the open economy model, it could be said that inflation combines internal and external factors, in another words, inflation is a composition of the domestic inflation plus imported inflation, thus:

$$\pi_t = \pi_{d,t} + \pi_{im,t} \quad (2)$$

Imported inflation may be caused by foreign price increases or depreciation of a country's exchange rate. Both are well captured in terms of trade variable, as a ratio of export to import price indices<sup>16</sup>. Taking first difference in terms of trade shows a change in relative prices of imports, and it may be interpreted as a measure of imports' inflation, so equation (2) can be expressed as follows:

$$\pi_t = \pi_{d,t} + \chi \Delta TT_t \quad (3)$$

Since, the domestic inflation follows the same process as that of (1):

$$\pi_{d,t} = \omega_f E_t \pi_{d,t+1} + \lambda_0 s_t + \omega_b \pi_{d,t-1} + \mu_{1t} \quad (4)$$

Where, by inserting in the equation (2), we get:

$$\pi_t = \omega_f E_t \pi_{d,t+1} + \lambda_0 s_t + \omega_b \pi_{d,t-1} + \chi \Delta TT_t + \mu_{1t} \quad (5)$$

From (3)  $\pi_{d,t} = \pi_t - \chi \Delta TT_t$ , the equation (5) may be written as:

$$\pi_t = \omega_f E_t (\pi_{t+1} - \chi \Delta TT_{t+1}) + \lambda_0 s_t + \omega_b (\pi_{t-1} - \chi \Delta TT_{t-1}) + \chi \Delta TT_t + \mu_{1t}.$$

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<sup>16</sup>We follow Galí and Monacelli (2005) and use inverse definition of the terms of trade.

Finally, the hybrid NKPC model for an open economy<sup>17</sup> can be expressed as<sup>18</sup>:

$$\pi_t = \omega_f E_t \pi_{t+1} + \omega_b \pi_{t-1} + \lambda_0 s_t + \chi \Delta T T_t - \chi \omega_f E_t \Delta T T_{t+1} - \chi \omega_b \Delta T T_{t-1} + \mu_{1t} \quad (6)$$

Two extreme cases arise: 1) when,  $\omega_b = 0$ , and 2)  $\omega_f = 0$ . In the first case, added external factors show ascending impacts on the actual inflation, and in the second case the converse of this; i.e., the downward impacts, but if change in TOT of current period always exceeds its expected and lagged ones.

To estimate the open economy version of the hybrid NKPC (equation 6) using TVP regression model with stochastic volatility, first of all we have to remove problems related to the expectations of inflation ( $E_t \pi_{t+1}$ ).

Assuming rational expectations and that the residual from the equation (6)  $\mu_{1t}$  is identically and independently distributed (i.i.d.),  $E_t \pi_{t+1}$  is replaced by the actual inflation  $\pi_{t+1}$  and orthogonality conditions are imposed between the residual and a set of instruments that are correlated with the regressors in (6) and not with the  $\mu_{1t}$ .

However, the future expected inflation is replaced by the actual one creates endogeneity bias<sup>19</sup>, because the future inflation is correlated with the error term (eq. 6).

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<sup>17</sup>In the TVP regression, the imported inflation ( $\chi$ ) as a time-invariant is estimated and assumed that it is integrated with the backward- and forward-looking components.

<sup>18</sup>If we say that  $\chi \omega_f = \theta_1$  and  $\chi \omega_b = \theta_2$ , then  $\theta_1 / \chi = \omega_f$  and  $\theta_2 / \chi = \omega_b$ .

<sup>19</sup>To take a difference between the observable future inflation and the latent variable, i.e.  $\pi_{t+1} - E_t \pi_{t+1} \equiv \eta_{t+1}$  and the plug in (6) get:  $\pi_t = \omega_f \pi_{t+1} + \omega_b \pi_{t-1} + \lambda_0 s_t + \chi \Delta T T_t - \chi \omega_f E_t \Delta T T_{t+1} - \chi \omega_b \Delta T T_{t-1} + \xi_t$ , where  $\xi_t \equiv \mu_{1t} - \omega_f \eta_{t+1}$ .

### 3.2 Estimation Procedure

To estimate the hybrid variant of the NKPC model, a two-step procedure is set up. In the first step, the future inflation is estimated on a set of instruments using OLS like Kim (2006) for storing standardized residuals<sup>20</sup>. In the second step, the standardized residual adds to the equation (6) to estimate the time-varying parameters in the TVP framework. Formulation of the TVP model with stochastic volatility is referred to in Nakajima (2011), Hall, Hondroyannis, Svamy and Tavas (2008). The model has the following form:

$$y_t = r_t' d + u_t' a_t + \nu_t$$

where  $\nu_t \sim N(0, \sigma_t^2)$ ,  $t = 1, \dots, n$ .

Where,  $y_t$  is scalar of response, in our case - the actual current inflation;  $r_t$  and  $u_t$  are  $(k \times 1)$  and  $(p \times 1)$  vectors of covariates, respectively. For instance,  $u_t \equiv (\pi_{t+1}, \pi_{t-1}, s_t)$ ;  $d$  is  $(k \times 1)$  vector of constant coefficients; The effects of  $r_t$  on  $y_t$  are assumed to be time-invariant, while the impact of  $u_t$  on  $y_t$  are assumed to change over time.  $a_t$  is a  $(p \times 1)$  vector of time-varying coefficients:

$$a_t \equiv (\omega_{f,t}, \omega_{b,t}, \lambda_{o,t})'$$

The time-varying coefficients follow the first-order random walk which allows both permanent and temporary shifts in the coefficients:

$$a_{t+1} = a_t + \mu_t$$

where  $\mu_t \sim N(0, \Sigma)$ ,  $t = 0, \dots, n - 1$ .

Assuming an  $AR(1)$  process for the time-varying coefficients ensures that

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<sup>20</sup>Estimating time-varying coefficients, variation in the volatility of the error term is allowed

the coefficients not to be over-fit if the relations of  $u_t$  on  $y_t$  are ambiguous<sup>21</sup>.

The error term in the regression follows the normal distribution with the time-varying variance  $\sigma_t^2$  (stochastic volatility), which is modeled as

$$\sigma_t^2 = \eta \exp(h_t)$$

$$h_t = \log \sigma_t^2 / \eta$$

$$h_{t+1} = \phi h_t + \psi_t$$

where  $\psi_t \sim N(0, \sigma_\psi^2)$ ,  $t = 0, \dots, n - 1$ .

The TVP model forms a non-linear state space process<sup>22</sup>. Similar to Nakajima's Bayesian approach, the MCMC algorithm with N iterations' method is used to obtain the maximum likelihood estimates for each set of the above parameters<sup>23</sup>.

In the Bayesian inference, we specify the prior density,  $\pi(\theta)$ , for a vector of the unknown parameters  $\theta$ . If  $f(y | \theta)$  is the likelihood function for data  $y = \{y_1, \dots, y_n\}$ , inference is then based on the posterior distribution,  $\pi(\theta | y)$ , which is obtained by the Bayes' theorem:

$$\pi(\theta | y) = \frac{f(y | \theta) \pi(\theta)}{\int f(y | \theta) \pi(\theta) d\theta}.$$

The prior information,  $\theta$ , updated by observing the data  $y$ .  $\int f(y | \theta) \pi(\theta) d\theta$

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<sup>21</sup>See more with Nakajima (2011).

<sup>22</sup>For a precise and efficient estimation of the mode the author uses the programming codes that are written by Nakajima for Ox. However, some slight changes to these codes are executed.

<sup>23</sup>In cases when the variance of disturbance is time-invariant using Kalman filter for linear Gaussian state space model easily gives estimations of the parameters (West & Harrison 1998).

is the marginal distribution or can be called the normalizing constant. In the case when the likelihood function or the normalizing constant is intractable, the posterior distribution does not have a closed form. Therefore, using the MCMC sampling method overcomes this problem and enables us to sample from the posterior distribution without computing the normalizing constant<sup>24</sup>.

The most compelling reasons, using the Bayesian inference and the MCMC sampling method to estimate TVP regressions, are i) First of all, in fact, it is impossible to assess the normalizing constant, and further, the likelihood function is intractable because the model includes the nonlinear state equations of stochastic volatility; ii) since the MCMC method samples the parameters  $\theta$  and the state variables  $a$  and  $h$  simultaneously, enables us to make the inference for the state variables with the uncertainty of the parameters  $\theta$ .

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<sup>24</sup>See more with Nakajima (2011).



## 4 Data

The NKPC estimates reported here are based on quarterly time series data over the period of 1996:Q1-2012:Q4, which were put together from different sources, namely, National Statistics Office of Georgia (GEOSTAT), National Bank of Georgia (NBG), Ministry of Finance of Georgia (MoF), and International Monetary Fund (IMF). Some time series, like terms of trade ( $TOT$ )<sup>25</sup>,  $GDP$  gap<sup>26</sup> are derived by the author<sup>27</sup>.

As the measure of inflation rate, the rate of growth in  $GDP$  deflator is used<sup>28</sup> as a dependent variable<sup>29</sup>. Given the stochastic nature of seasonality in Georgian data for  $GDP$  deflator, this variable was subjected to seasonal adjustment by either seasonal dummies or  $X12$  procedure. Rather, for measuring inflation rate, the forth difference<sup>30</sup> of  $GDP$  deflator ( $X_t - X_{t-4}$ ) was used. A stochastic seasonal adjustment ( $X_t - X_{t-4}$ ) may accomplish two goals: a) handling the seasonal issue based on the dynamic properties of the Georgian data; and, b) directly incorporating the seasonal behavior in the underlying dynamic molding exercise.

$GDP$  gap is used as a proxy of marginal cost to estimate the hybrid NKPC in the TVC estimation.

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<sup>25</sup> $TOT$  is a ratio of import prices over export's one. Due to the fact that GEOSTAT doesn't provide these two indices, a strategy for getting the variable is the following:  $GDP$  by production approach ( $Y = C + I + G + X - IM$ ) which is represented by GEOSTAT only in nominal term,  $GDP$  deflator and Consumer Price Indices ( $CPI$ ) are applied on the components by the following way: Real term of the export ( $X$ ) and the  $GDP$  ( $Y$ ) were derived by using  $GDP$  deflator, for the consumption ( $C$ ) and the investment ( $I$ ) -  $CPI$ . Import in the identity is a residual (the author's calculation).

<sup>26</sup> $GDP$  gap as the deviation of actual output from the potential output is measured by Kalman filter, see the procedures of calculation in appendix 2.

<sup>27</sup>Prior to the use of the data, all variables are seasonally adjusted by using a version of the  $X12$  procedure in Eviews 7.

<sup>28</sup>Year-on-year growth in % ( $\log(gdp-def) - \log(gdp-def(-4))$ ). There is skimpy support in using consumer price index to measure inflation and estimate the hybrid NKPC because it reveals poor compatibility with other macro variables in the TVP modeling.

<sup>29</sup>Figure 3 in appendix 1 depicts plots of these variable.

<sup>30</sup>An advantage of using fourth difference is that, this procedure allow of stochastic seasonality to be directly modeled without much assumption that is the characteristic of using deterministic seasonal dummies or procedures such as the  $X12$ .

In the first step, a set of lagged variables is used to estimate the expected inflation rate. It consists of one lag of real money growth  $M3$  and two lags of real  $GDP$  <sup>31</sup>. After storing standardized residuals in OLS, then, it applies in the TVC step.

All variables appear to follow some stationary processes<sup>32</sup> (Figure 3, appendix 1), while the time-varying environment is inherently non-stationary.

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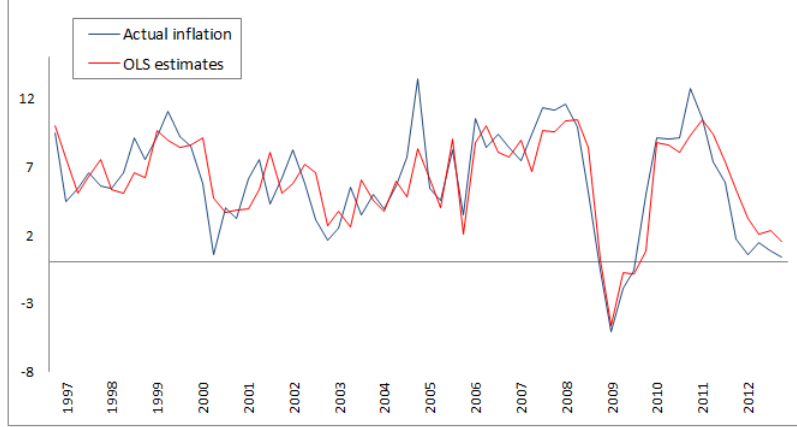
<sup>31</sup>In addition, there are exploited dummies of one period ahead of the Rose Revolution and the global financial crisis.

<sup>32</sup>The Augmented Dickey-Fuller (ADF) test conducted on the 1996Q1–2012Q4 sample can reject the null hypothesis of non-stationarity.

## 5 Results

Figure 1 shows the OLS estimates<sup>33</sup>.

Figure 1: Actual Inflation versus OLS Estimation



After storing standardized residuals and inserting them into the TVP regression model, we get estimations of the time-varying parameters with stochastic volatility<sup>34</sup>. Results are shown below<sup>35</sup>. To ensure the soundness of the reported estimates, it is useful to compute inefficiency factors, i.e., the convergence diagnostics (CD) of Geweke (1992). These were shown to be quite low (all is lower than 100), thus, indicating efficient sampling for the parameters and state variables.

The analysis of inflation dynamics shows that inflation in Georgia is mainly forward-looking in nature<sup>36</sup>. The coefficient  $\omega_f$  varies between 0.5-0.6 until 2009. After the National Bank's move to inflation targeting (IT) regime, forward-looking inflation starts a gradual increase and reaches at its maximum of 0.7

<sup>33</sup>Diagnostics tests of residual see in appendix 1.

<sup>34</sup>Estimation results of the hybrid version of NKPC model by using GMM routine are shown in appendix 1, table 1. The findings did show no significant support for the NKPC slope (GDP gap as a proxy of the real marginal cost).

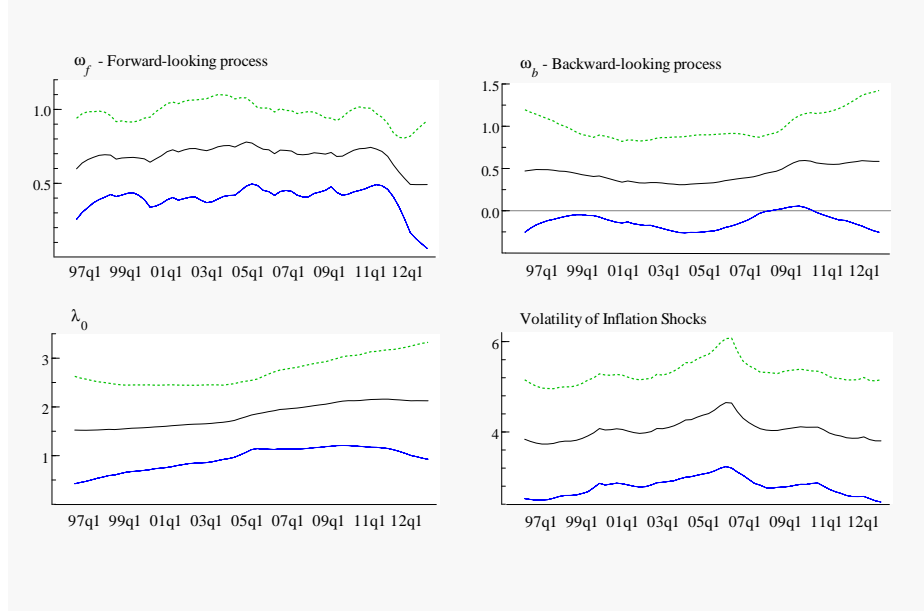
<sup>35</sup>See the sample autocorrelation function in appendix 1, figure 5.

<sup>36</sup>It is significant over the entire time span. Clear pictures of the time-varying parameters on the entire period is showed in appendix 1, figure 6.

Table 1: TVP Regression Model with Stochastic Volatility

Estimation Result						
Parameter	Mean	Stdev	95%L	95%U	Geweke	Inef.
b1	0.3775	0.1317	0.1207	0.6434	0.675	8.57
Sig11	0.0066	0.0041	0.0021	0.0171	0.805	15.44
Sig22	0.0124	0.0127	0.0026	0.0469	0.617	24.83
Sig33	0.0179	0.0223	0.0029	0.0718	0.933	41.52
Phi	0.8602	0.1062	0.5998	0.9881	0.748	17.73
Siget	0.1158	0.0487	0.0593	0.2397	0.693	46.03
Gamma	3.6936	1.0816	1.6775	6.041	0.164	18.93
tvpr.ox						
TVP regression with stochastic volatility						
Iteration: 10000						

Figure 2: Time-Varying Parameters



during the period of 2009Q2-2011Q3. This was a good signal for the IT. Setting a benchmark inflation rate of 6%, could have been recognized as a short-term inflationary expectation by the society. But then, it changed trajectory remarkably and dropped at 0.49 levels, which may be expressed as a challenge for the NBG to revise the benchmark of inflation expectations <sup>37</sup>. On the other hand, backward-looking inflation component,  $\omega_b$ , exhibits considerable time variation and in total shows less inflation inertia. It shows insignificant decreasing tendency from 0.4 to 0.3 until 2007, after that the coefficient peaks at almost 0.6 in the first three quarters of 2009 (it is significant over the period of 2007Q3-2009Q3). Then, the backward-looking term moves opposite to its counterpart. Since 2010 the estimates of the coefficient  $\omega_b$  became (again) insignificant; there are periods when inflation rate jumped up after the financial crisis and when it sharply moved into deflation in 2012. It is interesting that the persistency of inflation re-started an increase when inflation rate had been fixed below the target of 6%.

Inflation volatility spikes in those periods, when: i) high foreign direct investment (FDI) inflows took place in Georgia during 2005-2007. The highest number of FDI - 2,015 million USD (19.8% of GDP in 2007, 15.3% of GDP in 2006) was reached in 2007. Of course, high investment inflows has several advantages since it contributes to the generally scarce capital resources, works as a driving force to increase the transfer of technology and therefore productivity, skills development, reduction in unemployment and so on, but, when suddenly a huge amount of investments come into a small country like Georgia, it brings immediate appreciation of the national currency, increasing path to price levels and in turn, it influences negatively on exports (however, in fact,

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<sup>37</sup>Since February, 2012 Georgia has been involved in Deflation (year-on-year changes). [http://geostat.ge/cms/site\\_images/\\_files/english/price/CPI%20Press%20release\\_08%202013\\_Eng.pdf](http://geostat.ge/cms/site_images/_files/english/price/CPI%20Press%20release_08%202013_Eng.pdf). From 2015 the national bank of Georgia is going to reduce the benchmark of IT and set it at 5%. In the long-run, the inflation target will gradually decrease to 3 percent.

the effect of unanticipated exchange rate fluctuations on export appears later). In 2007, Georgia experienced high inflation (11%, end of period) and currency appreciation against the US dollar (7%, end of period) with a high growth rate of real GDP (12.3%). The digit growth rate was a result of FDI inflows, the economy was overheated<sup>38</sup>, and ii) Georgia was engaged in a war with Russia and the global financial crisis started (2008q4-2009q4). In 2009, the inflation rate sharply dropped at 3% (end of period) and for the first time, the country experienced negative GDP deflator (-2%). Therefore, the two peaks of inflation shocks indicate high uncertainty of the future path of inflation. After the adoption of IT, the stochastic volatility tendency moved downward.

Similar to other countries, the inflation rate influences real economic activity in Georgia as well. The slope coefficient,  $\lambda$ , which measures real economic activity's influence on inflation rate, is positive on the entire time span and significant. These results are opposite to GG (1999) and Galí (2002) findings who found insignificant coefficient for the output gap. GG (1999) and Galí (2002) used GDP gap as a proxy for real marginal cost and estimated the hybrid NKPC by GMM techniques for the US and Euro areas. Among other things, the failure to find a significant estimate by GG and Galí may be attributed to the incorrect measure of the output gap variable. In this paper, the estimation of the GDP gap is derived under the Kalman filter.

Regardless of the possible overestimation concerns, there is an important implication of these findings that one cannot underestimate for the Georgian economy. In Georgia, the output gap is a driving factor for its inflation as suggested by the hybrid NKPC model. This is also supported by the deflation in 2012 that is associated with the negative GDP gap (i.e., lower level of real economic activity).

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<sup>38</sup>See figure 7 in appendix 1.

Overall, examination of the inflation dynamics in Georgia shows that Georgian economy (or its inflationary dynamics) may be characterized by a predominantly forward-looking behavior. However, the Georgian economy has witnessed a deflationary period that is challenging its monetary authorities. Facing the new realities, the National Bank of Georgia must revise its benchmark of the inflation target, which is 6 percent and continue implementation of a credible monetary policy regime, which takes into account a stable forward-looking nature of the inflationary process while avoiding undue output volatility.

## 6 Conclusions

The results of estimating the hybrid NKPC nested in the TVP regression model provides important insight into the inflation dynamics in the Georgian economy. The reported investigation of the inflation dynamics show that, before the NBG adopts an inflation targeting regime, the forward-looking component of the inflation had a stable behavior. However, during the same period, the backward-looking component of the inflation term (inflation persistence) had started to rise rapidly. This was mainly because of the unexpected positive internal and external shocks that occurred after the “Rose Revolution” in 2003. Later on, the adoption of an inflation targeting regime in 2009 by the NBG, the degree of inflation persistence went down and forward-looking term reached its maximum level. This implies that the NBG well anchored inflationary expectations to its medium term inflation target. However, the NBG’s inflexible monetary implementation (unchanged aggressiveness), especially after the third quarter of 2011, might have caused these two components to reverse their behaviors. When evidence shows that the actual inflation is well too far from its optimal target, then the monetary authorities might need to be flexible in reviewing and possibly revising their inflation-targeting regime and its benchmark inflation target of 6%. The findings in this paper also reveal real economic activities as measured by the GDP gap impacts the inflation rate in Georgia. Nonetheless, the findings in this paper might be improved if the hybrid NKPC model is nested in a multivariate TVP framework. This clearly provides a direction for the future research in this area.



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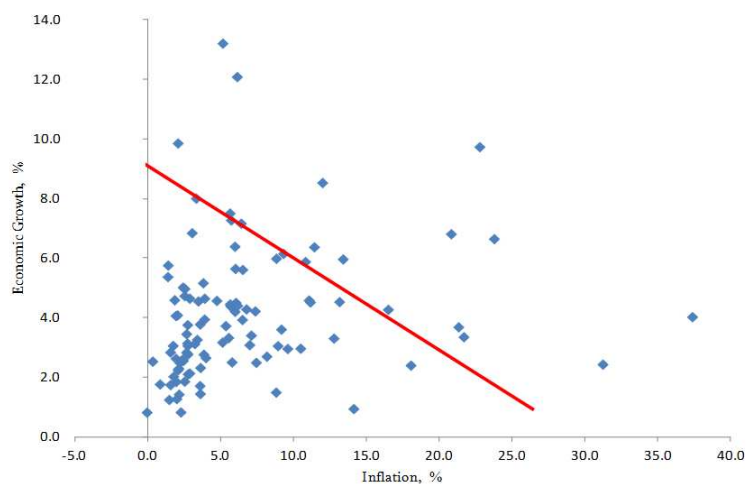
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# Appendix 1:

## Graphical Representations

Figure 1: Inflation and Economic Growth (1996-2010)



The graph shows a relationship between inflation and economic growth based on 112 countries' data.

Figure 2.

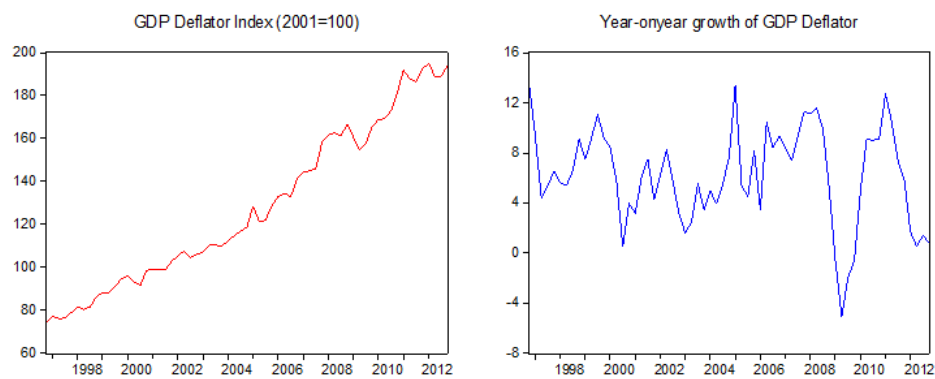


Figure 3.

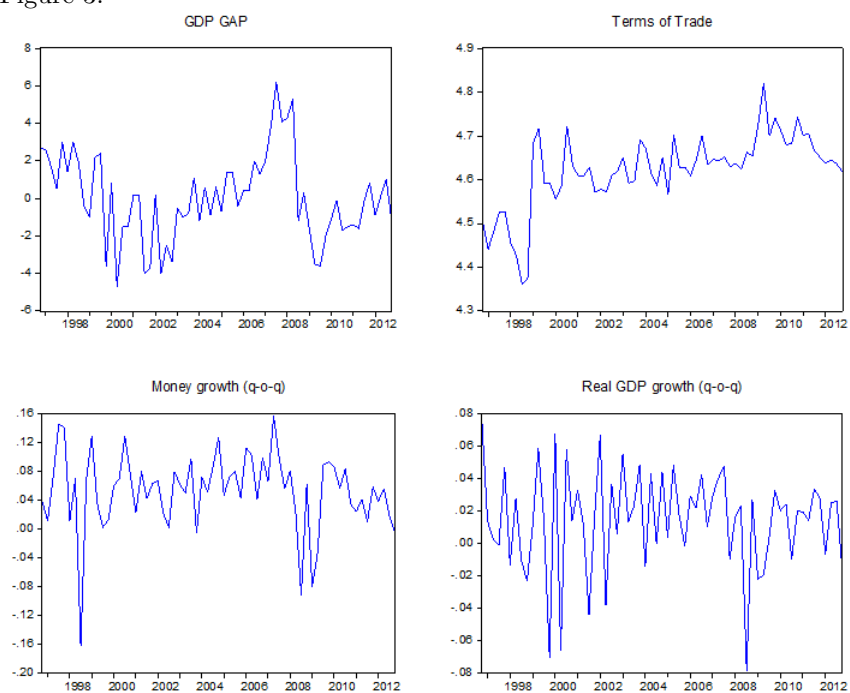
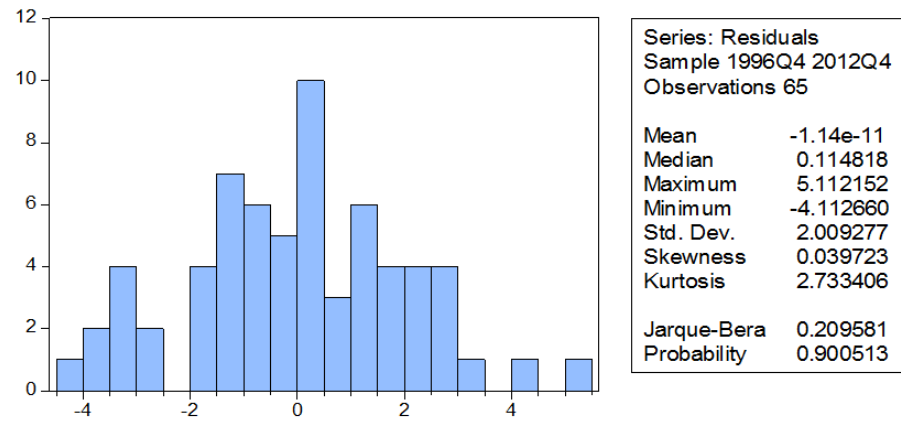


Figure 4. Residual Tests

a) Normality test



b) Serial Correlation test

Breusch-Godfrey Serial Correlation LM Test:			
F-statistics	0.080827	Prob. F(2,58)	0.9225
Obs*R-squared	0.177881	Prob. Chi-Square(2)	0.9149

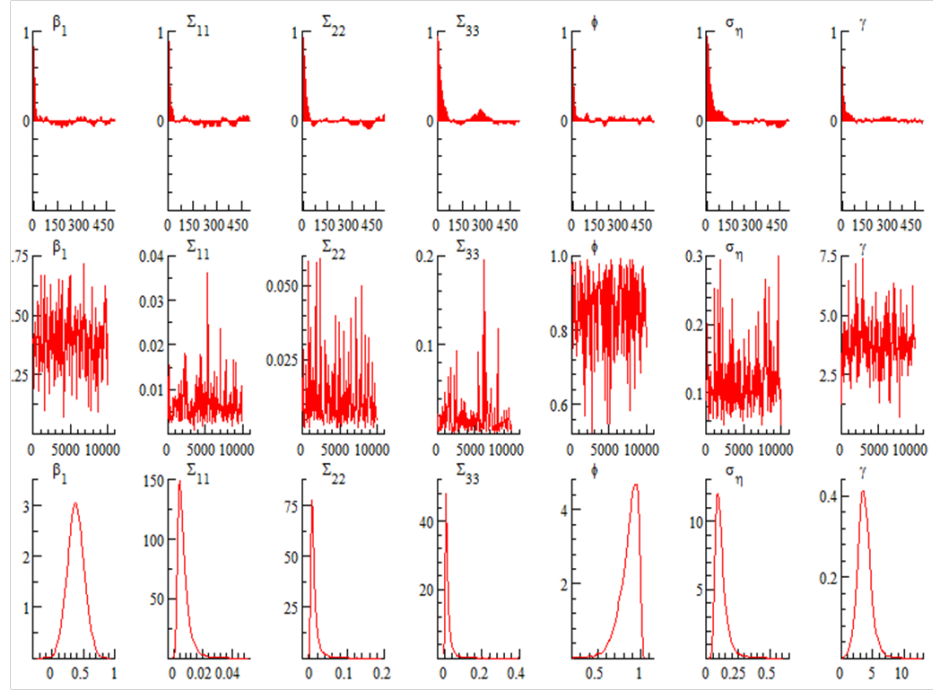
c) Heteroskedasticity test

Heteroskedasticity Test: Breusch_Pagan-Godfrey			
F-statistics	0.056941	Prob. F(2,61)	0.9447
Obs*R-squared	0.119261	Prob. Chi-Square(2)	0.9421
Scaled explained SS	0.205523	Prob. Chi-Square(2)	0.9023

Figure 5.

# Estimation Results of the TVP Regression Model

(with Stochastic Volatility)



The figure shows the sample autocorrelations drop stably, indicating that the sampling method efficiently produces the samples with low autocorrelation.



Figure 6.

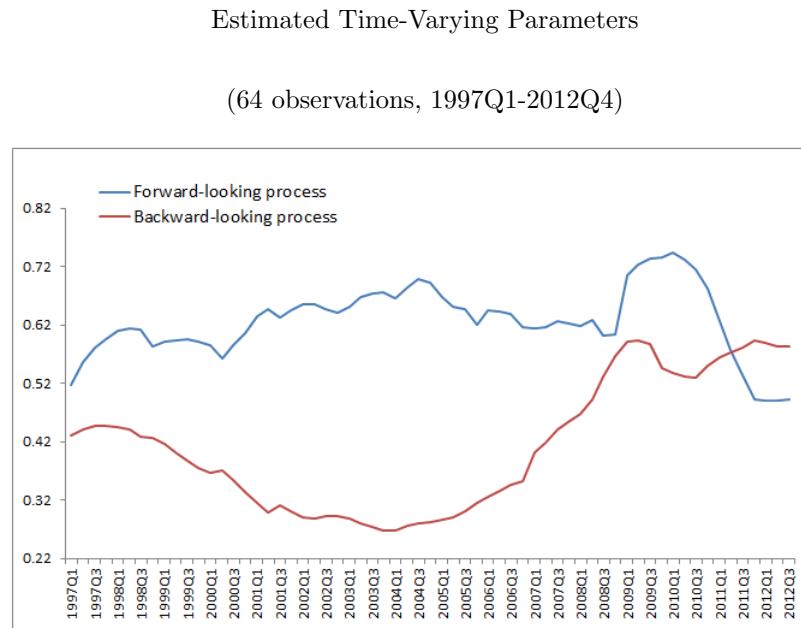


Figure 7.

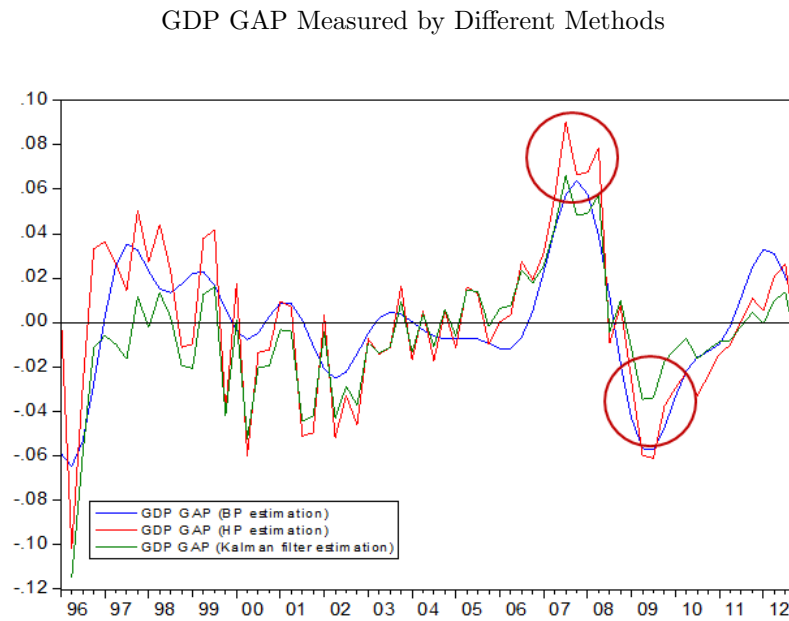


Figure 8.

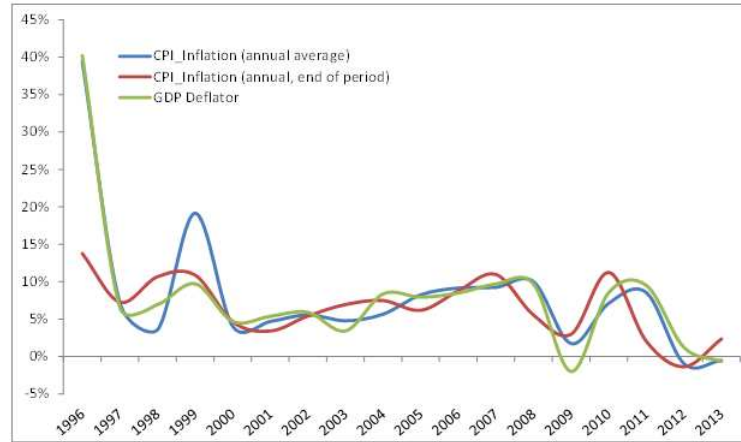


Table 1.

GMM Estimation of the Hybrid NKPC Model			
	Parameters		
	$\gamma_b$	$\gamma_f$	$\lambda$
<i>GDP Deflator</i>			
(1)	0.5665 (0.0134)	0.4332 (0.1101)	0.0001 (0.0006)
(2)	0.3360 (0.1320)	0.6656 (0.1329)	-0.0008 (0.0008)
(3)	0.2599 (0.3141)	0.7432 (0.3161)	-0.0012 (0.0020)

**Note:** Sample period: 1996q1-2012q4. Standard errors in parentheses. The row (1) corresponds to estimates using as instruments: money growth rate, real GDP, unit labor cost, nominal effective exchange rate, crude oil prices, interest rate spread and lagged GDP deflator (t-5); the row (2) corresponds to estimates using as instruments: money growth rate from t-0 to t-1, real GDP (t-2) and GDP deflator from t-3 to t-5; and the row (3) corresponds to estimates using as instruments: money growth rate (t-1), real GDP (t-2) and GDP deflator (t-3).

Table 2.

Contrasts in Literature			
Source	Methodology	County	Data
Gali and Gertler (1999)	NKPC model estimated via Generalized Method of Moments (GMM).	U.S.	Quarterly data over the period 1960q1-1997q4. To measure Inflation they use the GDP deflator.
Gali, Gertler and Lopez-Salido (2001)	Hybrid NKPC model estimated via Generalized Method of Moments (GMM).	Euro Area; U.S.	Quarterly data over the period 1970q1-1998q2. To measure Inflation they use the GDP deflator.
Gali and Monacelli (2005)	They performed an open economy version of the NKPC model by adding a forcing variable -Terms of trade.	N/A	N/A
Mihailov, Rumler and Scharler (2011a)	Assessing the small open-economy NKPC derived in Gali and Monacelli (2005).	Austria, Canada, France, Germany, Italy, the Netherlands, Spain, Sweden, Switzerland and the UK.	Quarterly data over the period 1970q1-2007q4.
Rudd and Whelan (2005)	GMM method for assessing pure NKPC model	U.S.	Quarterly data over the period 1960q1-2004q3.
Mavroeidis (2005)	First, OLS for deriving residuals of regressing forcing variable (output gap) on inflation (four lags), then GMM method to estimate NKPC models	U.S.	Quarterly data over the period 1961q1-1997q4.
Lansing (2008)	Examining a form of boundedly-rational inflation expectations in the NKPC model by using Kalman filtering routines.	U.S.	Quarterly data over the period 1949q1-2004q4.
Cogley and Sbordone (2008)	Approaching an unrestricted VAR in the first step with drifting parameters and stochastic volatility, and then estimating the pricing model by exploiting cross-equation restrictions on the VAR	U.S.	The sample covers the period 1954q1-2003q4.
Hondroyannis, Swami, Tavlás (2009)	Time-varying coefficient (TVC) framework to estimate the hybrid NKPC.	France, Germany, Italy and the UK	The sample covers the period 1970q4-2005q1 for the UK and 1971q1-2005q2 for others.
Baxa, Plasil and Vasicek (2012)	Bayesian Model Averaging to derive standardized residuals of regressing future inflation on a set of instruments, and then applying time-varying-parameter (TVP) model to estimate closed and open economy versions of NKPC model.	Czech Republic, Hungary, Poland.	Quarterly data over the period 1996q1-2010q4.
Mladenovic and Nojkovic (2012)	Two-state Markov switching and univariate models are used to estimate monthly inflation rate	Slovakia, Czech Republic, Poland, Hungary, Romania and Serbia	Sample covers monthly data from January, 1995 to May, 2010 for Poland, Hungary and Slovakia, and a previous year, 1994, in the case of Czech Republic, for Romania - January, 2002 - June 2010 and for Serbia - January, 2003 - September, 2010.
Maliszewski (2003)	Error-Correction Model (ECM) for Inflation	Georgia	Sample covers monthly data from January, 1996 to February 2003.

## Appendix 2:

### Measuring GDP GAP by Kalman Filter

The Kalman filter (known as linear quadratic estimation) uses measurements observed over time to produce estimates of unknown variables that tend to be more precise than those based on a single measurement alone. The filter is named for Rudolf E. Kálmán. As oppose to the univariate filters, Kalman filter (Hodrick Prescott and Band-Pass) uses more variables for estimating economic relationships among variables and expressing the stylized facts. The Kalman filter uses state-space framework for recovering latent variable which is supported by priors. The framework contains two kinds of equations: measurement equation – relationship between observed (signal) and unobserved (state/latent) variables and transition (state) equation - dynamics of the unobserved variables.

**Measurement equation:** A measurement equation may take the following form:

$$Y_t = M_t\delta_t + AX_t + \varepsilon_t;$$

$$\varepsilon_t \approx N(0, \sigma_t)$$

Where,  $Y_t$  is data;  $M_t$  - coefficients or data;  $\delta_t$  - unobserved state variable;  $AX_t$  - exogenous regressors and  $\varepsilon_t$  - error term.

**Transition equation:**

$$\delta_t = \mu_t + K\delta_{t-1} + \nu_t;$$

$$\nu_t \approx N(0, \sigma_t)$$

Where,  $\mu_t$ - is a drift;  $K\delta_{t-1}$ - AR(1) process for state variable;  $\nu_t$ - error term.

The Kalman filter allows for estimation the parameters by using the maximum likelihood function.<sup>39</sup>

For calculating output gap for Georgia some economic information is added by doing that by using the Phillips curve formulation. For the simplicity, it

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<sup>39</sup>Harvey (1991), Kim and Nelson (1999).

is assumed that the past and future expectation of inflation equally influence on the actual inflation. There are obtained inputs for priors and calibrations, and then state-space framework is elaborated in Eviews7<sup>40</sup> to measure GDP gap which is a more powerful estimation framework than those derived by univariate filters.

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<sup>40</sup>Codes for measuring GDP gap with calibration on Georgian data (Kalman tools):

```
@signal dot_cpi = dot_cpi_st
@signal lgdp = lgdp_gap + lgdp_eq
@state dot_cpi_st = 0.5*dot_cpi_st(-1) + (1-0.5)*dot_cpi_tar + 0.1*lgdp_gap(-1) + [var=3]
@state lgdp_gap = 0.7*lgdp_gap(-1) + [var=2]
@state lgdp_eq = lgdp_eq(-1) + 5.6/4 + [var=1]
@mprior m_prior.
@vprior v_prior
```

### Appendix 3.

#### The Derivation of the Hybrid Phillips Curve<sup>41</sup>

Assume a representative household has preferences given by  $\sum_{t=0}^{\infty} \beta^t U(C_t, L_t)$ , where  $C_t$  is consumption and  $L_t$ - labor, usual properties holds here. Without loss of generality the real wage can be expressed as follows:  $\frac{W_t}{P_t} = -\frac{U_{L_t}}{U_{C_t}} \mu_t^w$ , where  $-U_{L_t}U_{C_t}$  is the marginal rate of substitution between consumption and labor,  $\mu_t^w$  - the gross wage (can be price) markup ( $\mu_t^w \geq 1$ ).

On a competitive market  $\mu_t^w$  is observed equal to one, with labor market frictions  $\mu_t^w$  is larger than 1 and varying over time.

From the labor based production function derived the marginal product of labor which is  $(1 - \alpha)(Y_t/L_t)$ . ratio of the household's MC of labor supply to the MPL taking into account labor market friction yields the real marginal cost:

$$MC_t = -\frac{U_{L_t}/U_{C_t}}{(1 - \alpha)(Y_t/L_t)} \mu_t^w \quad (7)$$

Consider utility function is expressed like this:  $U(C_t, L_t) = \log C_t - (\frac{1}{1+\vartheta}) L_t^{1+\vartheta}$ . Taking partial derivative with respect to the consumption and labor separately, receives:

$$-U_{L_t}/U_{C_t} = -L_t^{\vartheta} C_t \quad (8)$$

Plug (8) into (7) and after log-linearization it yields:

$$mc_t = (w_t - p_t) - (c_t + \vartheta l_t) + [(c_t + \vartheta l_t) - (y_t - l_t)] \quad (9)$$

The expression  $[(c_t + \vartheta l_t) - (y_t - l_t)]$  is the log-linearized inefficiency wedge,  $(c_t + \vartheta l_t)$  - the MC of labor supply, the parameter  $\vartheta$ - the inverse of elasticity of

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<sup>41</sup>Galí, Gertler, Lopez-Salido (2001).

labor supply.

The inefficiency wedge can be related to the output gap, thus:

$$[(c_t + \vartheta l_t) - (y_t - l_t)] = -[(w_t - p_t) - (c_t + \vartheta l_t)] - [(w - p) - (c + \vartheta l)] + (1 + \vartheta)(y_t - y_t^*) \quad (10)$$

Where,  $y_t^*$  is output level with flexible prices and wages.

With notations,  $\log \mu_t^w = (w_t - p_t) - (c_t + \vartheta l_t)$  and  $\delta = 1 + \vartheta$  and substituting equation (10) into (9) one, the real marginal cost will be give by:

$$\widehat{mc}_t = \log(\mu_t^w / \mu^w) + \delta(y_t - y_t^*) \quad (11)$$

$\log(\mu_t^w / \mu^w)$  is percent deviation of the wage markup from its steady-state level and remark by  $\widehat{\mu}_t^w$ .

Combining eq. (11) with a basic Phillips curve,<sup>42</sup>  $\pi_t = \beta E_t(\pi_{t+1}) + \lambda \widehat{mc}_t$ , gives

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$$\pi_t = \beta E_t(\pi_{t+1}) + \lambda \widehat{\mu}_t^w + k(y_t - y_t^*) \quad (12)$$

where  $k = \lambda\delta$ . Then, following Calvo (1983) price approach, price index is

$$p_t = \theta p_{t-1} + (1 - \theta)p_t^* \quad (13)$$

where  $\theta$  price stickiness.

$$p_t^* = (1 - \omega)p_t^f + (1 - \theta)p_t^b \quad (14)$$

It means a fraction  $(\omega)$  of firms set price equal to the average of newly

---

<sup>42</sup>Galí, Gertler (1999).

<sup>43</sup>The new Phillips curve based on the output gap is correct only under  $\widehat{\mu}_t^w = 0$ .

adjusted prices last period plus an adjustment for expected inflation.

Forward-looking re-set price will be:

$$p_t^f = (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t \{ \widehat{mc_{t,t+k}} + p_{t+k} \} \quad (15)$$

$$\widehat{mc_{t,t+k}} = \widehat{mc_{t+k}} - \frac{\epsilon\alpha}{1-\alpha} (p_t^f - p_{t+k}) \quad (16)$$

Backward-looking re-set price:

$$p_t^b = p_{t-1}^* + \pi_{t-1} \quad (17)$$

where,  $\pi_t \equiv p_t - p_{t-1}$ .

From the (13) and (14), we get:

$$\pi_t = (1 - \theta) / \theta [(1 - \omega)(p_t^f - p_t) + \omega(p_t^b - p_t)] \quad (18)$$

Combining (15) and (16) yields:

$$p_t^f - p_t = (1 - \beta\theta) \xi \sum_{k=0}^{\infty} (\beta\theta)^k E_t \{ \widehat{mc_{t,t+k}} \} + \sum_{k=1}^{\infty} (\beta\theta)^k E_t \{ \pi_{t+k} \} \quad (19)$$

Parameter  $\xi = ((1 - \alpha) / (1 + \alpha / (\epsilon - 1)))$ .

Equation (13) with (17) yields:

$$p_t^b - p_t = 1 / (1 - \theta) \pi_{t-1} - \pi_t \quad (20)$$

Finally, equations (19) and (20) plugged into (18) derives the expression for inflation, which is:



$$\pi_t = (1-\theta)/\theta[\omega(\frac{1}{1-\theta}\pi_{t-1}-\pi_t)+(1-\omega)[(1-\beta\theta)\xi\sum_{k=0}^{\infty}(\beta\theta)^k E_t\{\widehat{mc_{t+k}}\}+\sum_{k=1}^{\infty}(\beta\theta)^k E_t\{\pi_{t+k}\}]] \quad (21)$$

In the compact form it takes the following form:

$$\pi_t = \tilde{\lambda}\widehat{mc_t} + \gamma_f E_t\{\pi_{t+1}\} + \gamma_b \pi_{t-1} \quad (22)$$

That is the hybrid New Keynesian Phillips Curve (NKPC).

Where,

$$\lambda \equiv (1-\theta)(1-\beta\theta)(1-\omega)\xi\phi^{-1}$$

$$\gamma_f \equiv \beta\theta\phi^{-1}$$

$$\gamma_b \equiv \omega\phi^{-1}$$

$$\phi \equiv \theta + \omega[1-\theta(1-\beta)].$$

Under the assumption  $\omega = 0$ , the hybrid NKPC becomes the pure NKPC.